NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

TECHNICAL NOTE 4294

EFFECTS OF NOSE SHAPE AND SPRAY CONTROL STRIPS ON EMERGENCE AND PLANING SPRAY OF HYDRO-SKI MODELS

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SUMMARY

The emergence- and planing-spray characteristics of flat-bottom surfaces representative of hydro-skis with various bow shapes and deflectors were investigated for trims of 12° and 20° and a speed of 30 feet per second. The emergence-spray characteristics of the models with various bow shapes were investigated for depths of submersion of the bow from 0.50 inch to -0.50 inch. The planing-spray characteristics of the models with the various deflectors were determined for a draft corresponding to a length-beam ratio of 4. The emergence- and planing-spray patterns are shown in the photographs taken from forward of and above the models and from the side of the models.

The most favorable emergence spray was obtained with a bow of triangular plan form and sharp profile. The greatest improvement in planing spray was obtained with vertical chine strips and a transverse barrier strip located forward of the wetted planing area.

INTRODUCTION

The spray generated by hydro-skis during emergence and at low planing speeds is one of the hydrodynamic problems associated with the application of hydro-skis to water-based aircraft. This spray can cause temporary loss of power and corrosion damage to propellers and engines, additional take-off resistance, or excessive loads on aerodynamic components. Heavy spray is generated by a hydro-ski at emergence and at low planing speeds because of the high trim angles usually required for the transition from submerged to planing operation. As a result of the high trim angles, the emergence spray would be expected to be largely dependent on nose shape. Beyond emergence the spray generated by the hydro-ski at low planing speeds is heavy because of the continued high trim angles and inherently high beam loadings and is largely influenced by the transverse shape of the hydro-ski bottom.

An experimental investigation was made in Langley tank no. 2 to determine qualitatively the effects on emergence spray of nose profile and plan-form shapes and the effects on planing spray of different transverse locations of longitudinal strips. Transverse barrier strips were also used in an attempt to control the spray in the planing condition which originates forward of the stagnation line and is thrown ahead of the leading edge of the surface.

MODELS AND APPARATUS

The model configurations are shown in figure 1. The models that represent variations in nose shape used for investigation of the emergence spray are:

(a) Model A - bow of rectangular plan form and 4:1 elliptical profile

(b) Model B - bow of rectangular plan form and sharp profile

(c) Model C - bow of 64° triangular plan form and sharp profile

(d) Model D - bow of 1.6:1 elliptical plan form and sharp profile

The models that represent a flat rectangular hydro-ski with various arrangements of longitudinal strips and transverse barriers used for investigation of the planing spray are:

(e) Model E - flat bottom

(f) Model F - longitudinal strips at chines

(g) Model G - longitudinal strips 0.50 inch inboard of chines

(h) Model H - longitudinal strips at chines and transverse spray barrier

(i) Model I - longitudinal strips 0.50 inch inboard of chines and transverse barrier

(j) Model J - longitudinal strips at chines with a 0.69-inch-radius flow reverser at bow

The longitudinal strips and the transverse barrier strips extended 0.25 inch below the bottoms of the models and the transverse barrier strips were located 12 inches forward of the trailing edge of the models.

The models were constructed by molding plastic around a mahogany core. This manner of construction resulted in sharp chines on all models. Each model had a beam of 2.50 inches and a plan-form area of 37.5 square inches. The cross section at the longitudinal center of the models was 0.75 inch in height.

The tests were made on the Langley tank no. 2 towing carriage. A photograph of the test setup is shown in figure 2. The models were supported by a polished stainless-steel strut which had an NACA 66_1-012 section with a chord of 2.60 inches and a length of 16.50 inches. Photographs of the spray were taken with two 70-millimeter still cameras. One camera was located forward of and above the model and the second was located directly to the side of the model and as close to the water surface as feasible. The photographs of the spray were taken simultaneously with both cameras.

PROCEDURE

The emergence-spray characteristics of the models with various bow shapes were determined by conducting tests at trims of 12° and 20° and depths of submersion d of the bow from 0.50 to -0.50 inches. The trims of 12° and 20° were chosen as representative trims for emergence. The depths of submersion were measured from the highest point on the bow to the water surface. When the bow of the model was above the water surface, the depths of submersion were indicated as negative. All tests were conducted at a speed of 30 feet per second, which corresponds to a Froude number of 12 in the range of pure planing.

The planing-spray characteristics of the models with modifications to the chines and bottom surfaces were determined by towing the models at trims of 12° and 20°, a wetted length-beam ratio of 4, and a speed of 30 feet per second.

RESULTS AND DISCUSSION

The results are presented in figures 3 to 6 as photographs of the spray which were taken from forward of and above the models and from the side of the models. The emergence-spray patterns of the models with various bow shapes (models A, B, C, and D) are shown in figure 3 for a trim of 12° and in figure 4 for a trim of 20°. The planing-spray patterns for the flat rectangular planing surface (model E) and the various modifications of this model (models F, G, H, I, and J) are shown in figure 5 for a trim of 12° and in figure 6 for a trim of 20°.

Emergence Spray

Emergence spray was formed when ventilation, with an accompanying flow separation, occurred on the submerged planing surfaces (figs. 3 and 4). After the separated flow was established, a decrease in the depth of submersion caused an increase in the height of the separated sheet. This process continued until, as the bow rose above the water surface, the separated sheet began to deteriorate into filaments of spray. When the bow pierced the sheet, chine spray and forward spray were formed.

The effect of bow profile shape on emergence spray can be determined by a comparison of the photographs of the models with an elliptical-profile bow (model A) and a sharp-profile bow (model B). Ventilation occurred on the elliptical-profile bow at a depth of submersion of -0.20 inch for a trim of 12° (fig. 3(a)) and at a depth of submersion of -0.40 inch for a trim of 20° (fig. 4(a)). The sharp-profile bow (fig. 3(b)) ventilated at a depth of submersion of 0 inch for a trim of 12° and at a depth of 0.50 inch for a trim of 20° (fig. 4(b)). As was expected, ventilation and separation occurred at a greater depth of submersion on the sharp-profile bow (model B). It may be of interest to note the process by which ventilation occurred on these two models. With the models submerged, the trailing vortices began to ventilate (figs. 3(a) and 3(b)) and as the depth of submersion decreased the air in the vortices approached the models. When the air reached the models, ventilation occurred. A process similar to this is described in reference 1. After ventilation had been established and as the depth of submersion decreased further, the separated sheet began to deteriorate and chine spray and forward spray were formed.

The effect of bow plan-form shape may be determined by comparing the photographs of the models having bows with sharp profiles and various plan forms. Ventilation had occurred on the bows with triangular (model C) and elliptical (model D) plan forms at a depth of submersion of 0.50 inch for the 12° trim. The model with a rectangular plan form (model B) ventilated at a depth of submersion of 0 inch for the 12° trim. Therefore, models C and D induced ventilation at a greater depth of submersion than model B. At a trim of 20° all of these models had ventilated at the 0.50-inch depth of submersion. For all trims and depths of submersion the separated flow and consequently the spray from model C did not rise as high above the water surface as it did for the other models. This may be attributed to a gradual buildup of bottom pressures on model C as compared with a sharp buildup of bottom pressures on model B. The height to which the spray rose for model D was between the spray heights of models C and B.

The piercing effect of the various bows must also be considered as a factor in determining the height to which the separated flow rises above the water surface. Because of the lower pressure at the point of the bow, model C pierced the separated flow and formed chine spray and forward spray at a greater depth of submersion than models B or D.

From the analysis of the photographs presented in the preceding discussion, it can be concluded that model C had the most desirable emergence-spray characteristics.

Planing Spray

Two distinct types of planing spray may be seen in figures 5 and 6. These two types of spray were chine spray, originating at the chines of the models, and forward spray, resulting from the flow along the bottom of the model forward of the stagnation line.

The application of chine strips or longitudinally mounted spray strips to flying boats and planing surfaces for controlling or directing chine spray is common practice. As expected, the thin longitudinal strips installed at the chines (see model F) were very effective in reducing the lateral and vertical displacements of the chine spray. The thin longitudinal strips attached 0.50 inch inboard of each chine (see model G) were not as effective as those attached at the chines. The longitudinal strips, in both cases, resulted in an increased volume of forward spray.

The models with spray barriers (models H and I) and the model with a semicylindrical flow reverser (model J) were very effective in reducing both the volume and the vertical displacement of the forward spray. The flow reverser had to be located at the bow and was therefore farther from the stagnation line than the spray barrier. Since the forward flow was more concentrated near the stagnation line, the spray barrier was more effective than the flow reverser.

In general, the preceding discussions apply to trims of both 12° and 20°. The principal difference between the planing-spray characteristics at a trim of 12° and those at 20° was the increased volume and displacements of the spray which occurred at the trim of 20°.

The greatest improvement in planing spray was obtained from the model (model H) with vertical chine strips and a transverse barrier strip located forward of the wetted planing area.

Practical Considerations

In a practical application the bow with the triangular plan form (model C) should not create any special problems, such as increased resistance or detrimental effects on planing spray. A planing surface with a flow reverser attached at the bow or a spray barrier located forward of the stagnation line could be used for planing operation without causing any detrimental effects. But for use on a planing surface requiring emergence through the water surface from submerged operation, the flow reverser or the spray barrier may have detrimental effects on emergence spray and resistance unless they are made retractable.

CONCLUDING REMARKS

The most favorable emergence spray was obtained with a bow of triangular plan form and sharp profile. The greatest improvement in planing spray was obtained with vertical chine strips and a transverse barrier strip located forward of the wetted planing area.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., March 14, 1958.

REFERENCE

1. Wadlin, Kenneth L., Ramsen, John A., and Vaughan, Victor L., Jr.: The Hydrodynamic Characteristics of Modified Rectangular Flat Plates Having Aspect Ratios of 1.00, 0.25, and 0.125 and Operating Near a Free Water Surface. NACA Rep. 1246, 1955. (Supersedes NACA TN's 3079 by Wadlin, Ramsen, and Vaughan and 3249 by Ramsen and Vaughan.)

(a) Model A (bow of rectangular plan form and elliptical profile).

(b) Model B (bow of rectangular plan form and sharp profile).

(c) Model C (bow of triangular plan form and sharp profile).

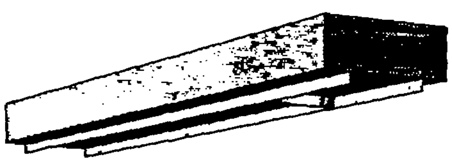
(d) Model D (bow of elliptical plan form and sharp profile).

(e) Model E (flat bottom).

(f) Model F (longitudinal strips at chines).

(g) Model G (longitudinal strips 0.50 inch inboard of each chine).

(h) Model H (longitudinal strips at chines and transverse barrier).



(i) Model I (longitudinal strips 0.50 inch inboard and transverse barrier).

(j) Model J (longitudinal strips at chines with flow reverser).

Figure 1.- Model configurations.

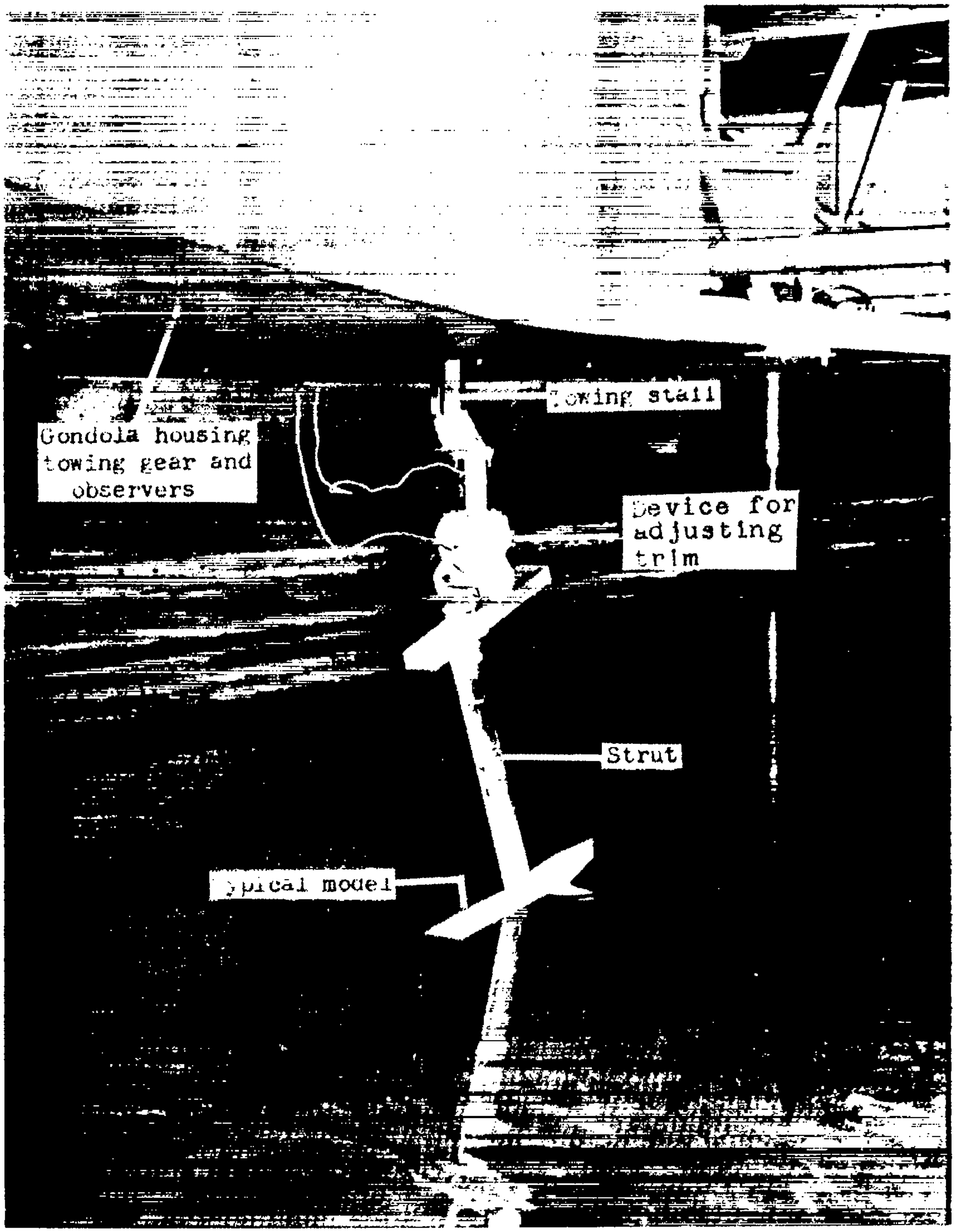
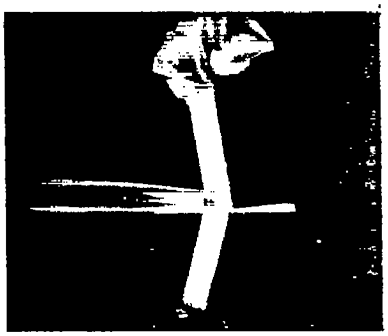
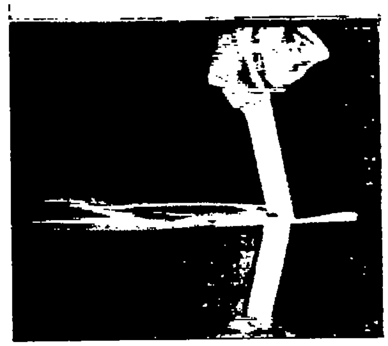


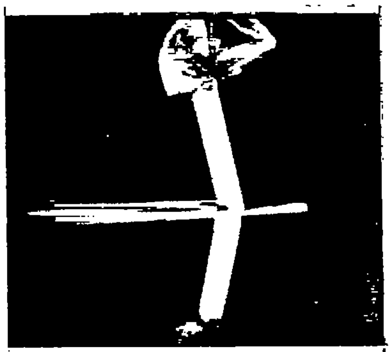
Figure 2.- Photograph of test setup. L-58-1613



d = 0.50 inch



d = 0.25 inch



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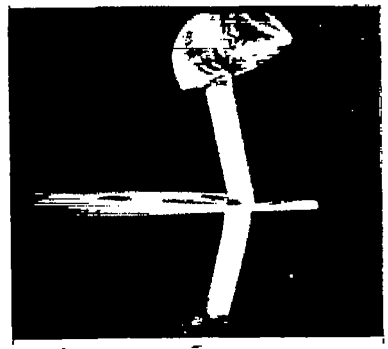

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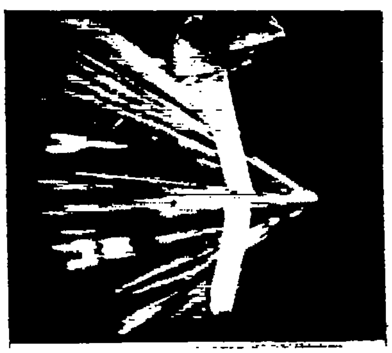


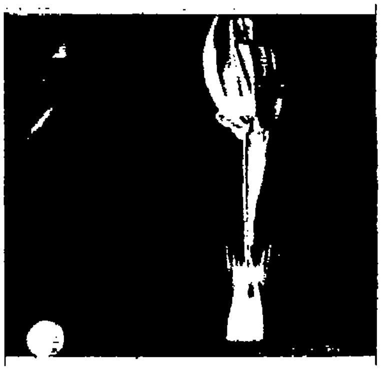
d = -0.20 inch

d = -0.50 inch

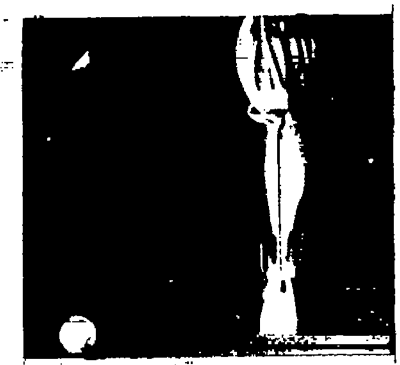
Camera located at side of model L-58-191

(a) Model A.

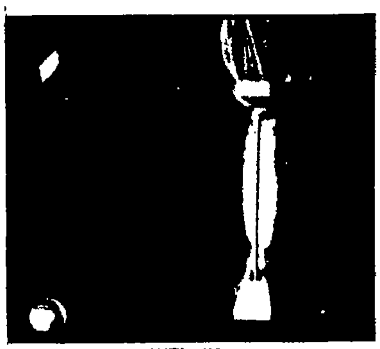
Figure 3.- Emergence-spray characteristics of models A, B, C, and D. Trim = 12°.



d = 0.50 inch



d = 0.25 inch



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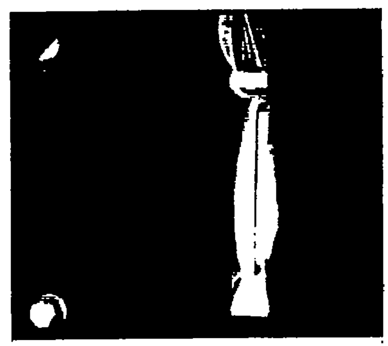

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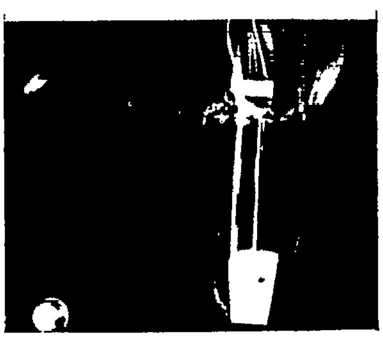


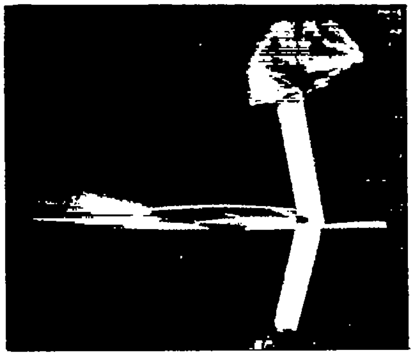
d = -0.20 inch

d = -0.50 inch

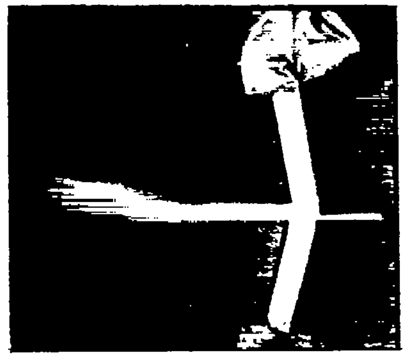
Camera located forward of and above model L-58-192

(a) Model A - Concluded.

Figure 3.- Continued.



d = 0.50 inch



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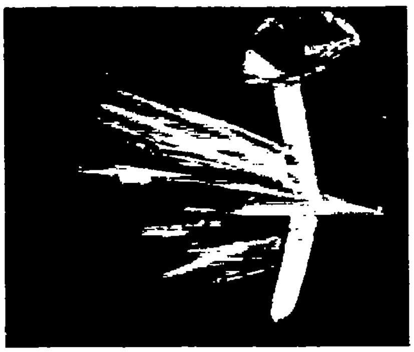
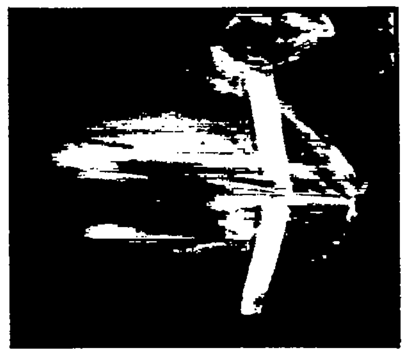


d = 0 inch



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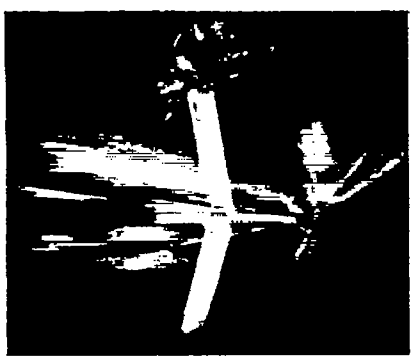
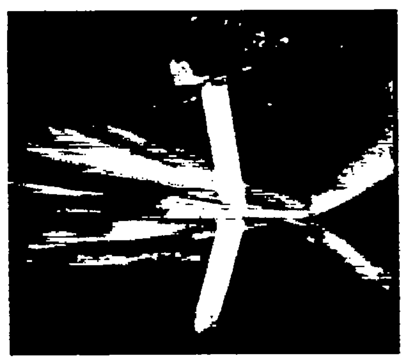


d = -0.20 inch

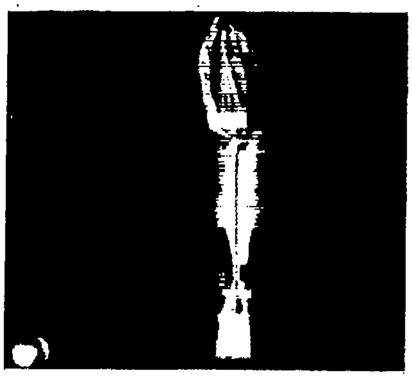


d = -0.50 inch

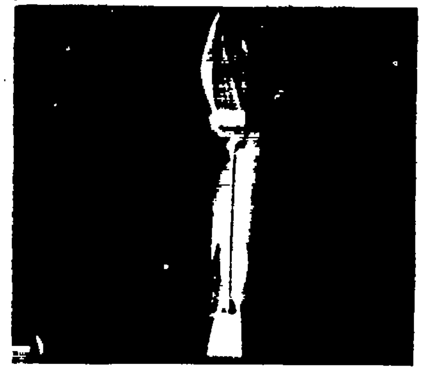
Camera located at side of model L-58-193

(b) Model B.

Figure 3.- Continued.



d = 0.50 inch



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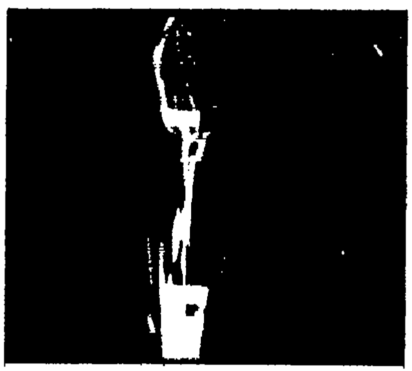


d = 0 inch

d = -0.10 inch

d = -0.20 inch

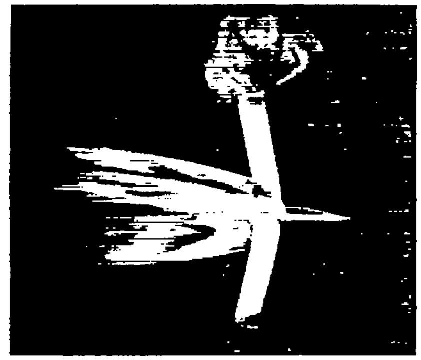
d = -0.50 inch

Camera located forward of and above model L-58-194

(b) Model B - Concluded.

Figure 3.- Continued.

d = 0.50 inch



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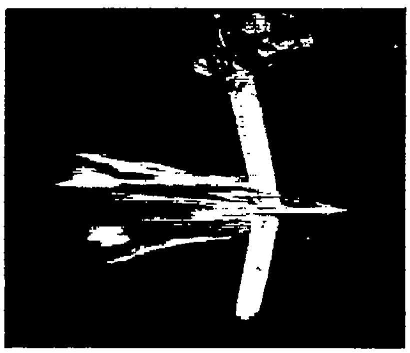

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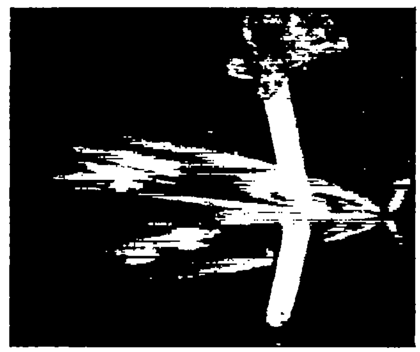

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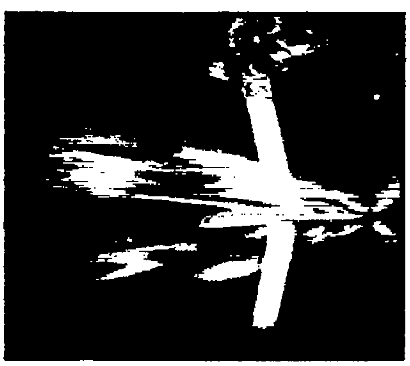

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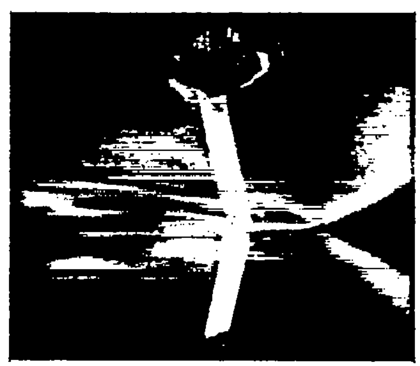
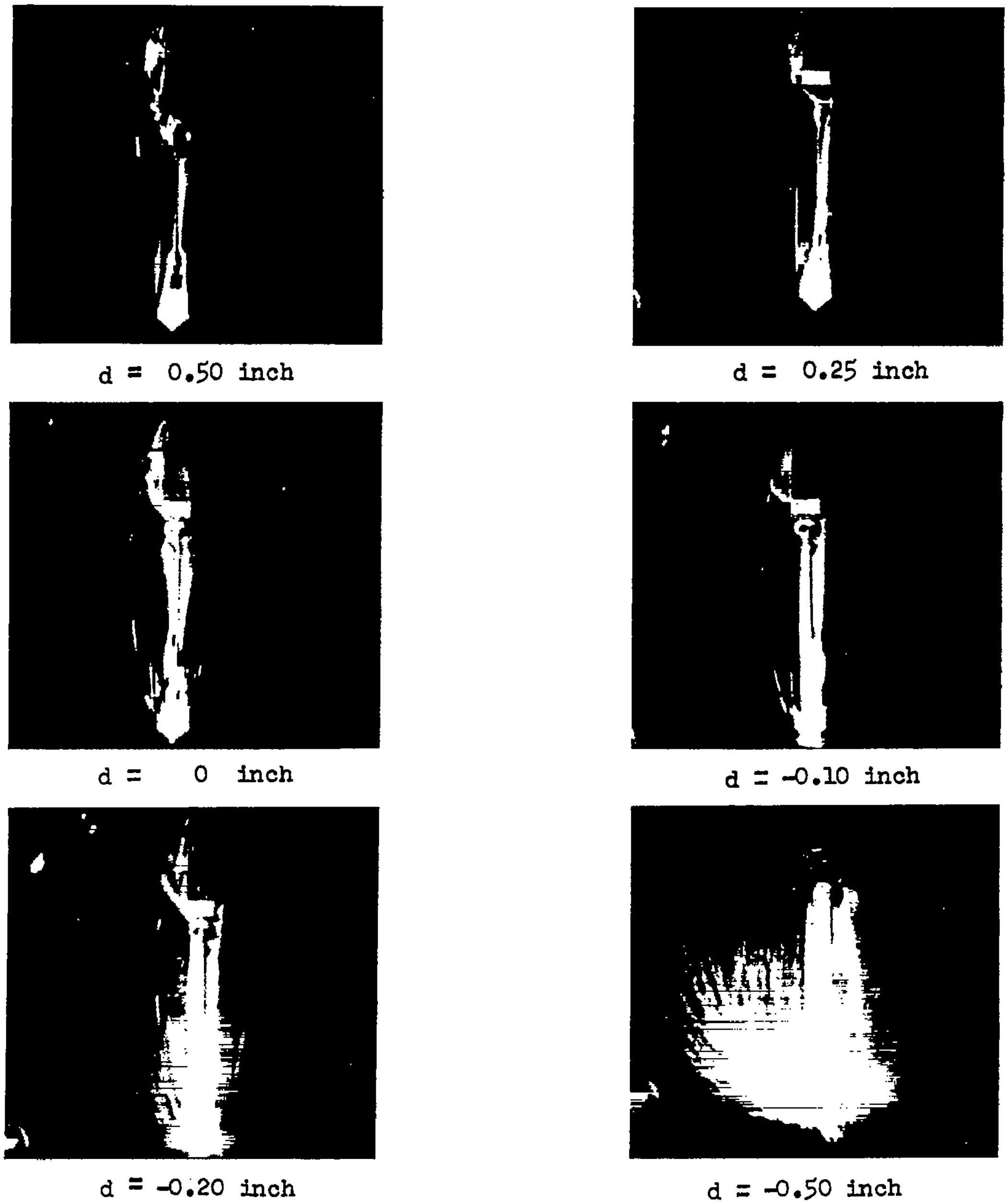


d = -0.50 inch

Camera located at side of model L-58-195

(c) Model C.

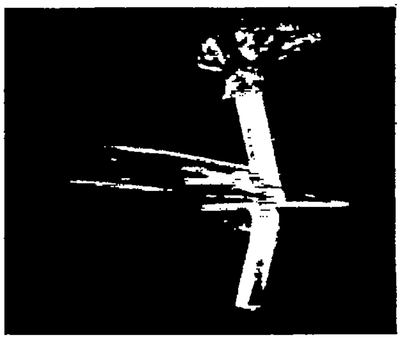
Figure 3.- Continued.



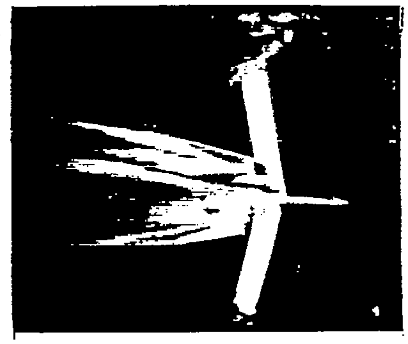
Camera located forward of and above model L-58-196

(c) Model C - Concluded.

Figure 3.- Continued.



d = 0.50 inch



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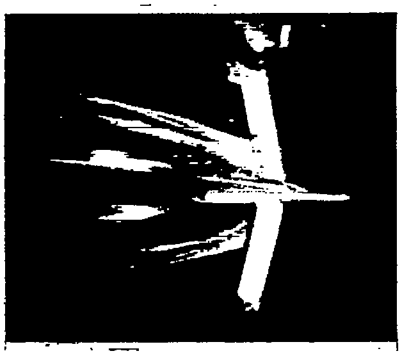
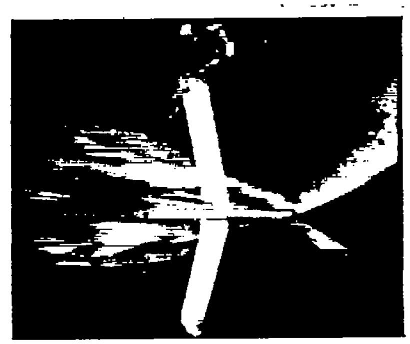


d = 0 inch

d = -0.10 inch

d = -0.20 inch

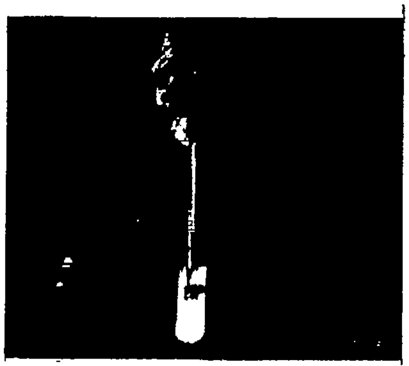


d = -0.50 inch

Camera located at side of model L-58-197

(d) Model D.

Figure 3.- Continued.



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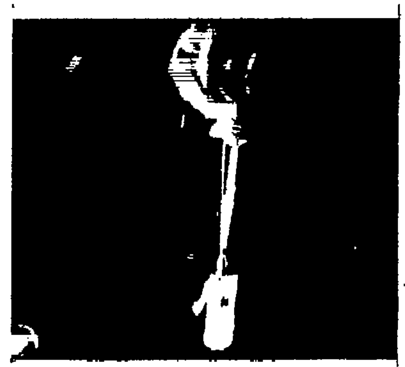

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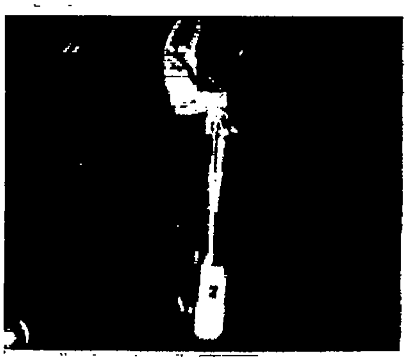

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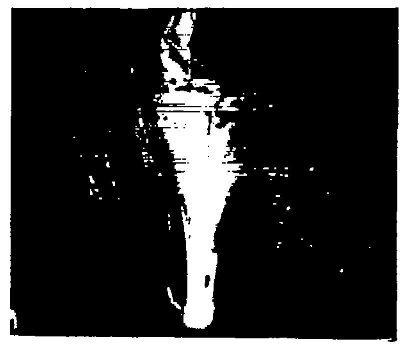

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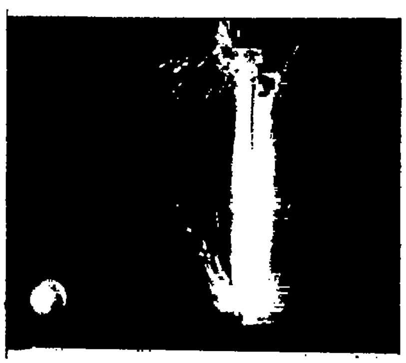


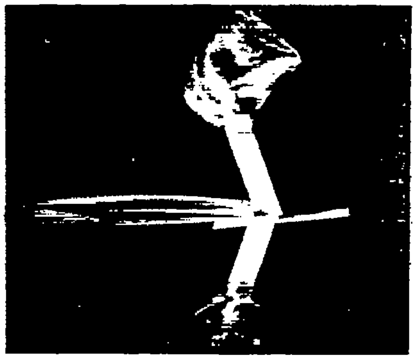
d = -0.20 inch

d = -0.50 inch

Camera located forward of and above model L-58-198

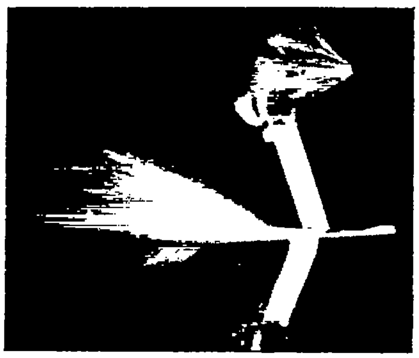
(d) Model D - Concluded.

Figure 3.- Concluded.

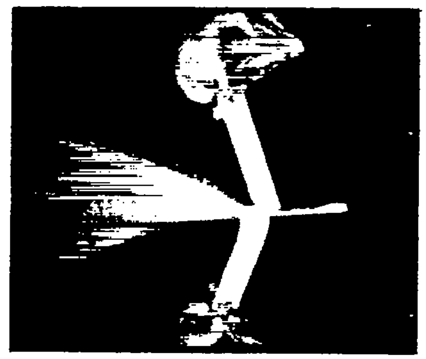


d = 0.50 inch

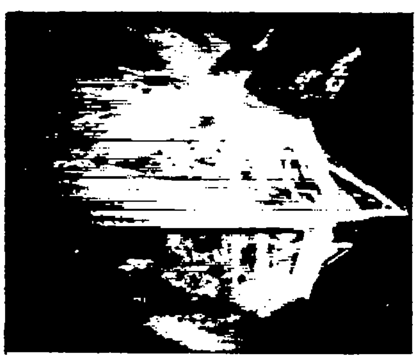
d = 0.25 inch



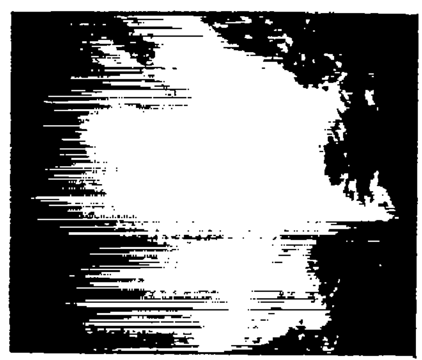
d = 0 inch



d = -0.20 inch



d = -0.40 inch

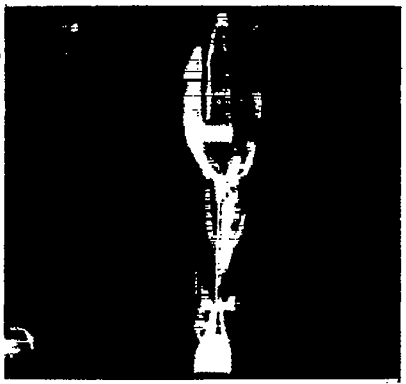


d = -0.50 inch

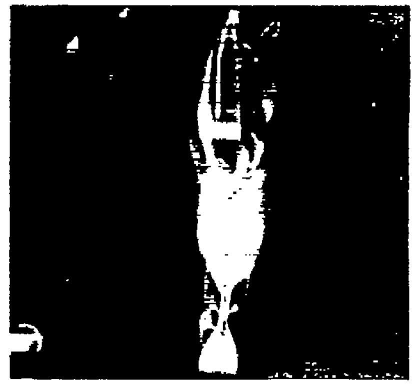
Camera located at side of model L-58-199

(a) Model A.

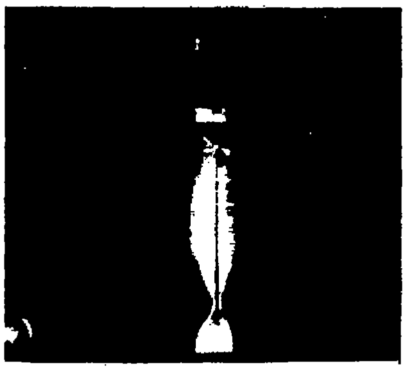
Figure 4.- Emergence-spray characteristics of models A, B, C, and D. Trim = 20°.



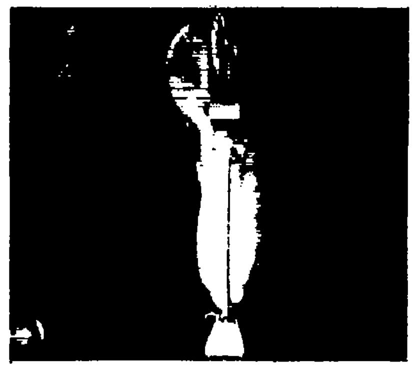
d = 0.50 inch



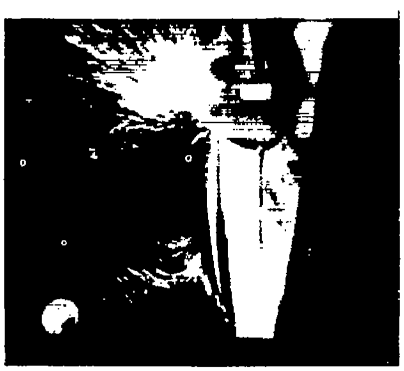
d = 0.25 inch



d = 0 inch



d = -0.20 inch



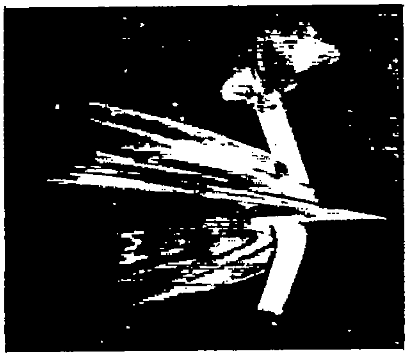
d = -0.40 inch

d = -0.50 inch

Camera located forward of and above model L-58-200

(a) Model A - Concluded.

Figure 4.- Continued.



d = 0.50 inch

d = 0.25 inch

d = 0 inch

d = -0.20 inch

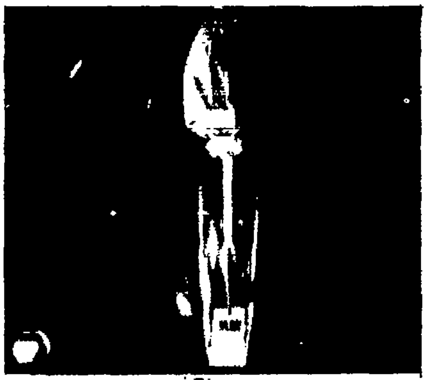
d = -0.40 inch

d = -0.50 inch

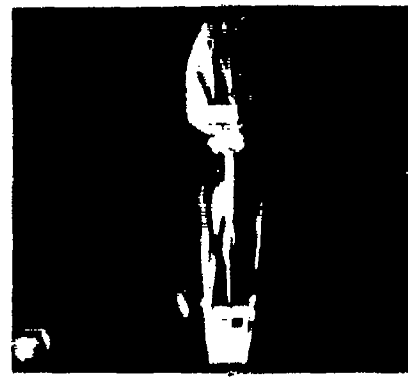
Camera located at side of model L-58-1600

(b) Model B.

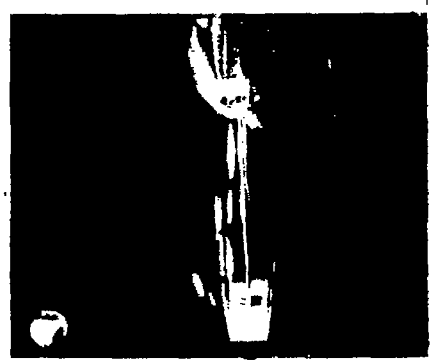
Figure 4.- Continued.



d = 0.50 inch



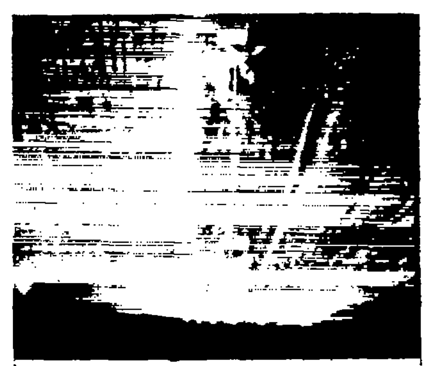
d = 0.25 inch



d = 0 inch

d = -0.20 inch

d = -0.40 inch



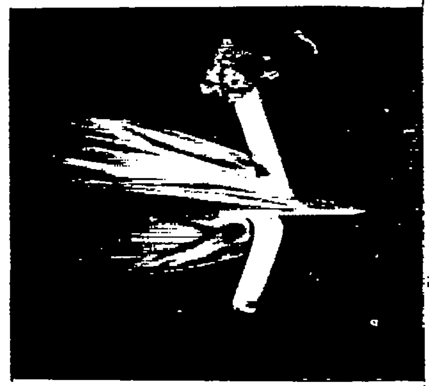
d = -0.50 inch

Camera located forward of and above model L-58-1601

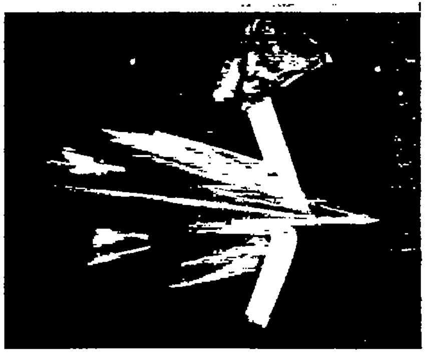
(b) Model B - Concluded.

Figure 4.- Continued.

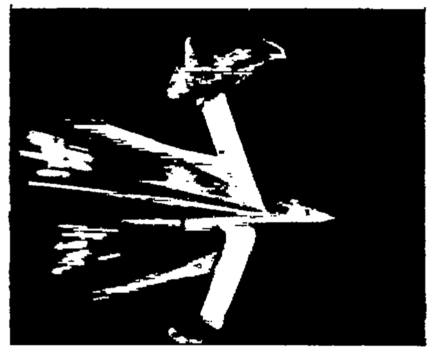
d = 0.50 inch



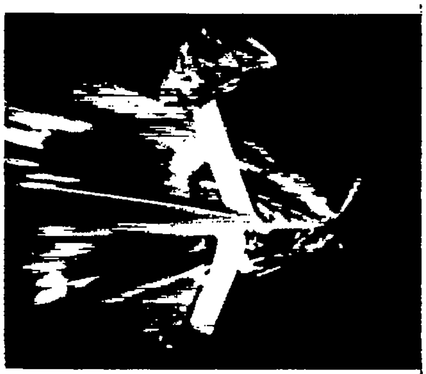
d = 0.25 inch



d = 0 inch



d = -0.20 inch



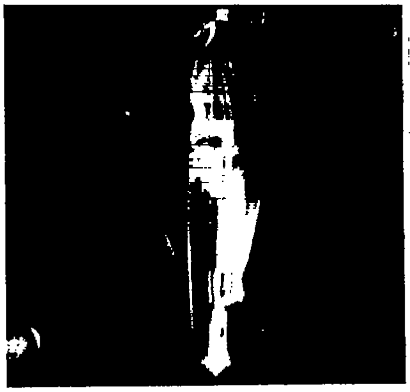
d = -0.40 inch

d = -0.50 inch

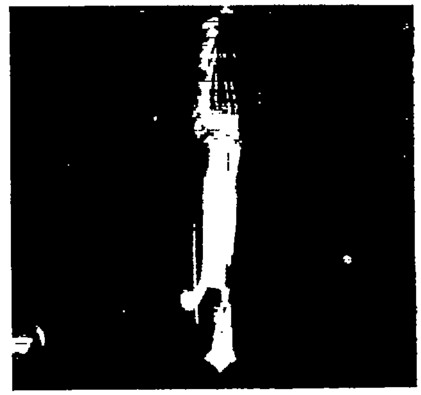
Camera located at side of model L-58-1602

(c) Model C.

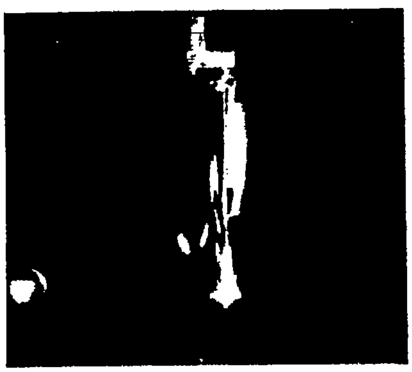
Figure 4.- Continued.



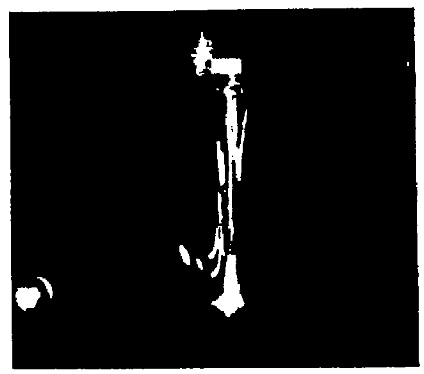
d = 0.50 inch



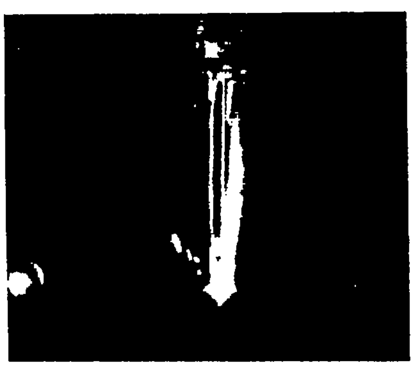
d = 0.25 inch



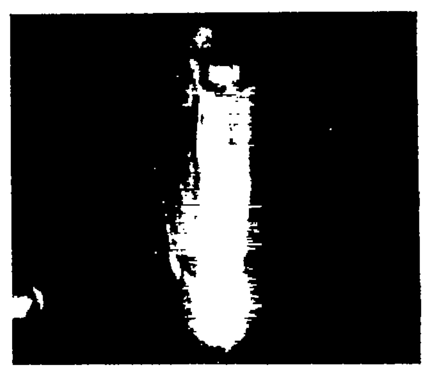
d = 0 inch



d = -0.20 inch



d = -0.40 inch

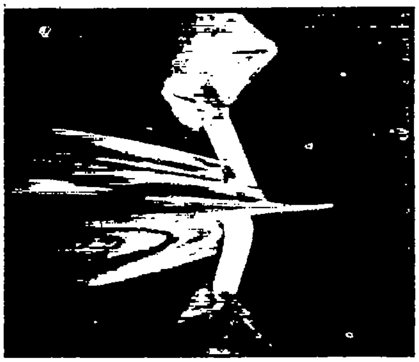


d = -0.50 inch

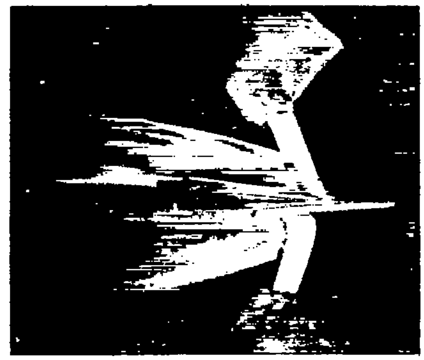
Camera located forward of and above model L-58-1603

(c) Model C - Concluded.

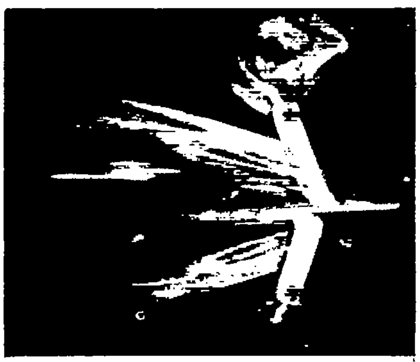
Figure 4.- Continued.



d = 0.50 inch



d = 0.25 inch



d = 0 inch

d = -0.20 inch

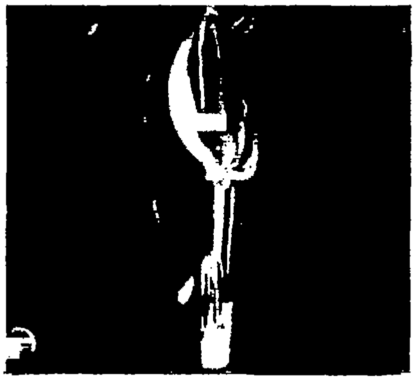
d = -0.40 inch

d = -0.50 inch

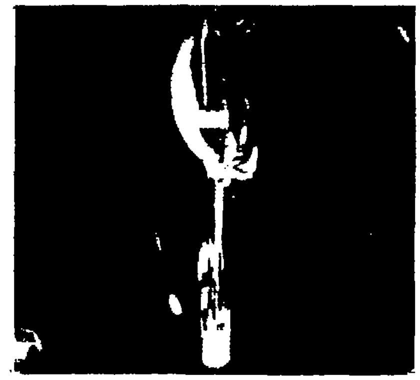
Camera located at side of model L-58-1604

(d) Model D.

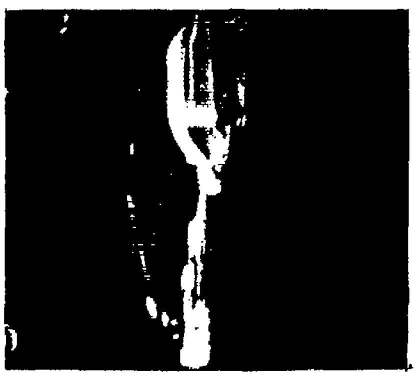
Figure 4.- Continued.



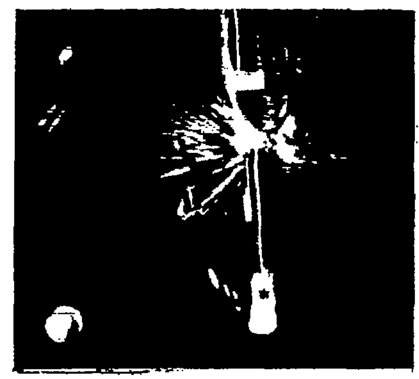
d = 0.50 inch



d = 0.25 inch

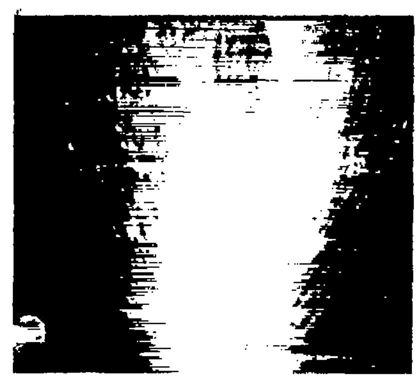


d = 0 inch



d = -0.20 inch

d = -0.40 inch

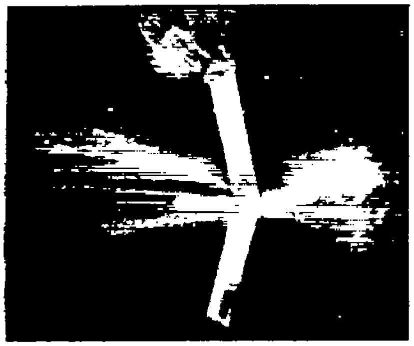


d = -0.50 inch

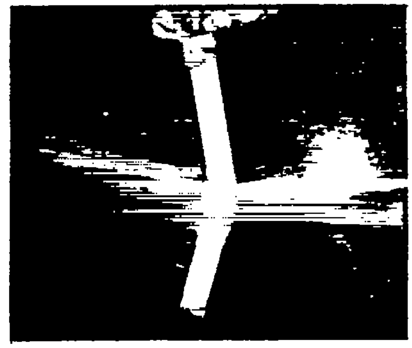
Camera located forward of and above model L-58-1605

(d) Model D - Concluded.

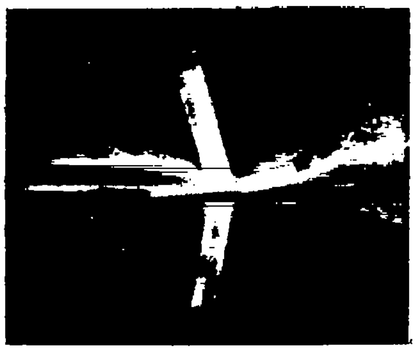
Figure 4.- Concluded.



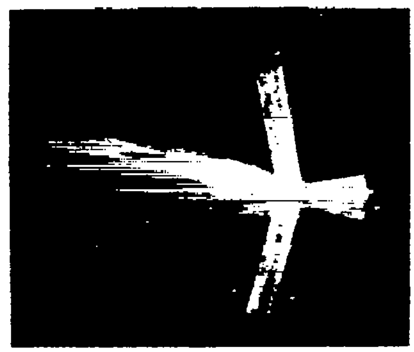
Model E



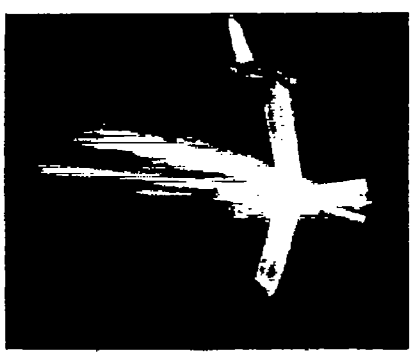
Model F



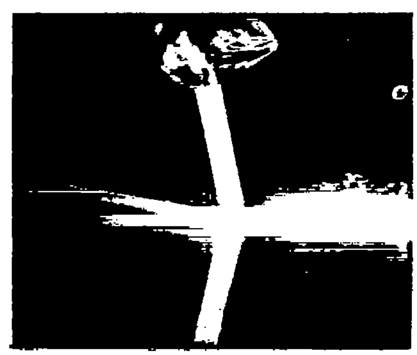
Model G



Model H



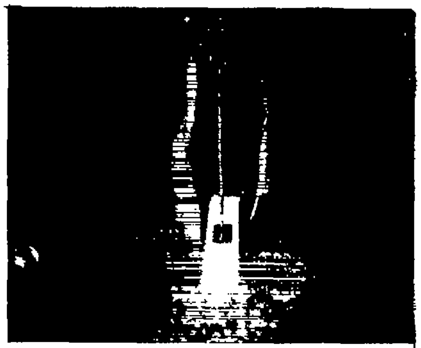
Model I



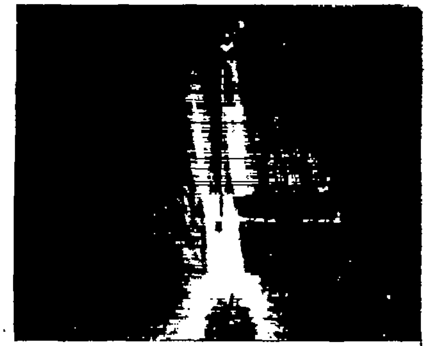
Model J

Camera located at side of model L-58-1606

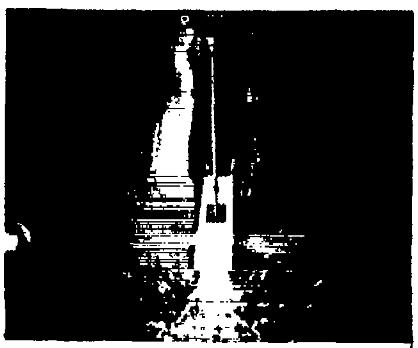
Figure 5.- Planing-spray characteristics of models E, F, G, H, I, and J. Length-beam ratio, 4; trim, 12°.



Model E

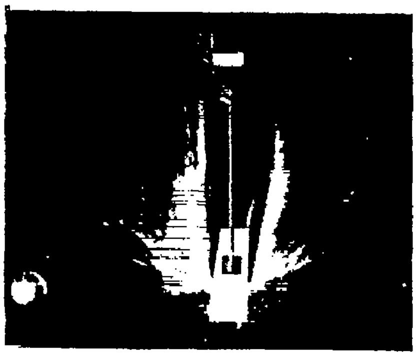


Model F

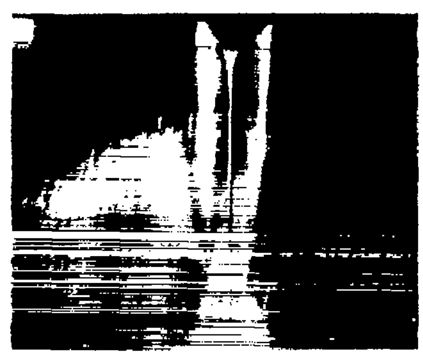


Model G

Model H



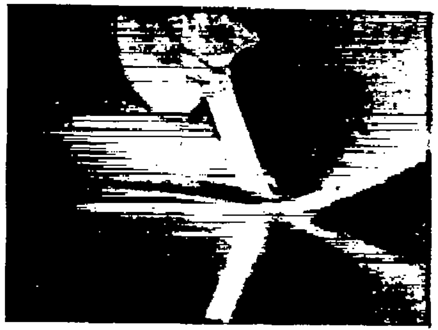
Model I



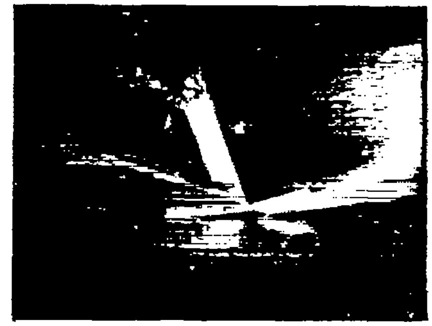
Model J

Camera located forward of and above model L-58-1607

Figure 5.- Concluded.

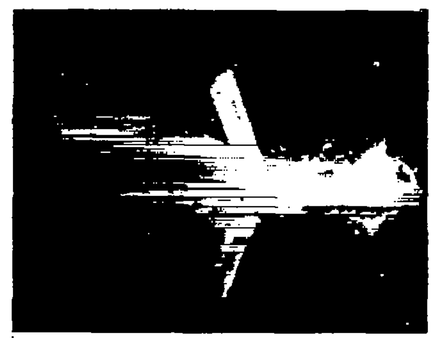


Model E

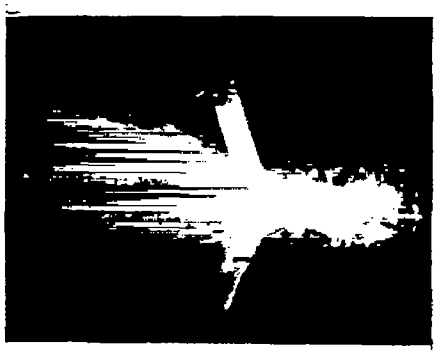


Model F

Model G



Model H

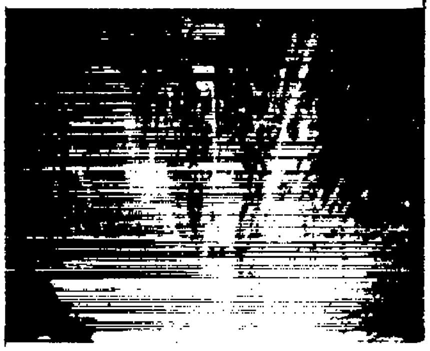


Model I

Model J

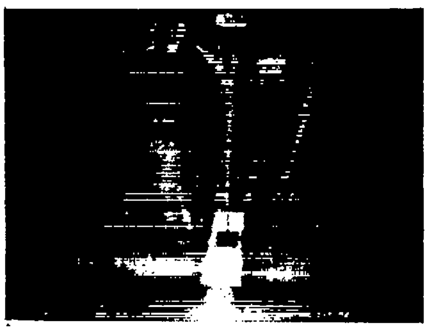
Camera located at side of model L-58-1608

Figure 6.- Planing-spray characteristics of models E, F, G, H, I, and J. Length-beam ratio, 4; trim, 20°.

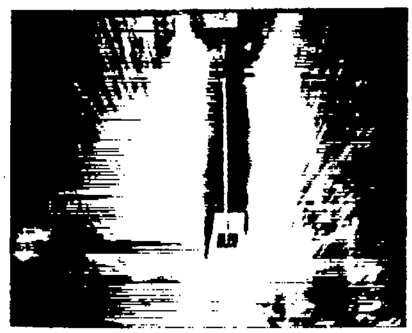


Model E

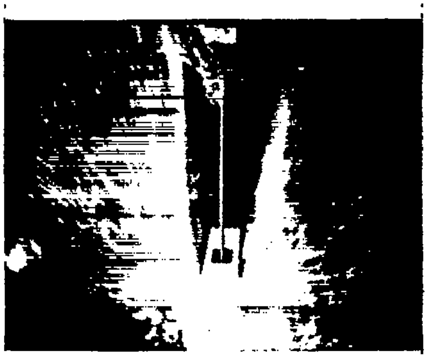
Model F



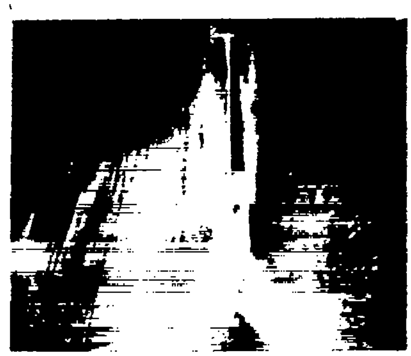
Model G



Model H



Model I



Model J

Camera located forward of and above model L-58-1609

Figure 6.- Concluded.